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ABSTRACT

In order to provide teachers and students with electronic learning environments that support mentoring and collaboration through electronic means, the authors developed software that supports same time/different place educational collaborative activities over the Internet. These activities focus on teaching students how to organize and systematize their explorations for information and to share this information with members of a group. The software is composed of an interface that connects the hyperlink, text, graphics, video, and sound capabilities of a browser to a World Wide Web client-server environment and is augmented by local electronic help tools and computer supported collaborative tools. Collaborative activities are supported through specially designed whiteboard, chat, file, and application sharing tools. Students can access online schedules and determine whether faculty or other students are available. The system is also equipped with management and record keeping capabilities that allow teachers or trainers to analyze various collaborative activities. Students enrolled in a variety of courses at the University of North Texas used the system to collaborate with other students and teachers. Information was logged concerning overall student performance, activities performed while using the collaborative systems, and attitudes related to technology and collaboration. Results were analyzed to determine which factors contributed to successful/unsuccessful collaboration. (MES)

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# Real-Time Collaboration over the Internet: What Actually Works?

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**Abstract:** While the growth of the Internet and collaborative software has greatly impacted the way students work together, little is known about what actually works and what doesn't. Some researchers argue that both structural and cultural problems impact effectiveness, while others suggest that a lack of "critical mass" may be affecting the results. This paper suggests that all of these things are true. In also contends that the type of task required of the group and collaborative style influences effective real-time collaboration. While this paper confirms that collaborative interfaces help most people work more effectively, it also shows that some groups are less successful, have fewer interactions, and remain hostile towards the system even though they complete the required task. More importantly, the results of our research raise additional questions about how technology can support distributed groups, and what is the nature of the mismatches.

## Introduction

As the number of distance learning and online courses continues to increase, we are being forced to re-examine the way we teach students to think. The idea of the "classroom teacher" is gradually being replaced by a web page or "talking head" that emanates from a remote site. Because of the rapid growth of this type of technology, we are beginning to question whether technology can support the in-depth contact between subject-matter expert and a small group of learners that is at the heart of our nation's peerless reputation in higher education. While both the Internet and other types of distance learning systems provide interesting pedagogical experiences, they lack many of the features that are associated with traditional educational classrooms such as laboratory exercises and small group discussions. If one of our goals is to improve education (Willis 1993), then we need find ways to provide teachers and students with electronic learning environments that support both mentoring and collaboration through electronic means.

In order to address this challenge, the authors developed special software that supports same time/different place educational collaborative activities over the Internet. These activities focus on teaching students how to organize and systematize their explorations for information and to share this information with members of a group. The software is composed of a unique interface that connects to the hyperlink, text, graphics, video and sound capabilities of a browser to a World Wide Web (WWW) client-server environment, and is augmented by local electronic help tools and computer supported collaborative tools. Collaborative activities are supported through specially designed whiteboard, chat, file and application sharing tools. Students can access online schedules and determine whether faculty or other students are available. The system is also equipped with both management and record keeping capabilities that allow teachers or trainers to analyze the various collaborative activities. Over 200 students enrolled in a variety of different courses at the University of North Texas used the system during the past year to collaborate with both students and teachers throughout the campus and different parts of the Metroplex. Information was logged concerning overall student performance, activities performed while using

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the collaborative system, and attitudes related to technology and collaboration. Results from these history files were then analyzed to determine which factors contributed to successful/unsuccessful collaboration.

While the past year's research show that collaborative interfaces help most groups work effectively, it also shows that some groups are less successful, perform fewer group interactions as compared to successful groups, or are uncomfortable with the system even after several hours of training. For example, we observed that some individuals completed the stated task but never shared information with other members of the group. Other subjects were disruptive, eventually causing the group to fail. In contrast, there were groups who learned how to complete tasks successfully, even when faced with adverse network conditions. Although the results of this research show that most distributed groups produced work that was indistinguishable from groups doing the same work face-to-face, some groups' performed poorly, some had members who never participated, and some work teams complained about the system, even though they performed well. Thus, over the course of two years, the authors have discovered many factors that both encourage and deter collaboration among students. The nature of these factors and how they impact effectiveness are discussed below.

## Relevant Literature

Much has already been accomplished in demonstrating the potential of using the Internet for educating, sharing, connecting, and communicating. For example, students enrolled in political science courses use the net to access large databases (Baker 1993; Newton 1993), students in high school use it to contact experts in the field (Press 1995), and students in business use it to learn about changing stock prices (Winner 1994). An ever increasing number of virtual classrooms are now available to students living in different cities or states (Huang 1997; Foster 1995). However, increasing educational opportunities have resulted in decreasing classroom time, and hence, decreasing the number of occasions where students and teachers interact with one another face-to-face. Thus, the question remains of how to make distance leaning environments support real-time educational activities such as academic advising, mentoring, laboratory experiments and small group exchanges (Reinhart 1995). While we know that network technology can be used to empower learners with the latest tools of the trade, we also know that it lacks the personal element that can give meaning to an educational experience. Thus, our prototypes and models must clearly demonstrate how network technology can evolve into an educational ecosystem of information, computation, communication, collaboration, and innovative mentoring. At the same time, the models must emphasize information access and visualization to provide easy derivation of an interactive information experience.

In response to these problems, the authors engaged in a number of innovative collaborative software projects sponsored by various funding agencies over the past several years (Swigger & Brazile 1995; Swigger et al., 1997). In order to enhance students' understanding of the cooperative process, we built several computer-supported cooperative interfaces that teach students how to cooperate more effectively in the accomplishment of specific tasks (e.g., library database searching, requirements elicitation, and cost center analysis). The cooperative interfaces all emphasize shared window systems (i.e., What You See Is What I See) that allow students who are geographically distanced from one another to work together at the same time. While several of the original interfaces proved effective, they did not support shared activities over the Internet. Thus, we developed an Internet-based tool that supports real-time collaborative learning over the network. The major focus of the research is on showing students and teachers how to work together over the Internet, and how to locate, synthesize, and analyze vast amounts of available

information. The long-term goal of the project, therefore, is to study what factors (in terms of both the interface and instructional materials) lead to effective collaborations. Thus, we are analyzing how teachers and students move from their specialized classrooms into shared, multi-user settings where diverse groups can collectively solve problems.

## Collaborative Software

As previously mentioned, the project's major objectives are (1) to develop software that allows students to collaborate, and (2) to determine whether the software can be effective in an educational setting. Thus, the first task, to develop software, has resulted in a series of programs that allows students to access special tools, libraries, and the network, to pose questions and conduct exchanges with teachers and other students in real-time. As a consequence, the system supports students who are located in different geographical areas, but who need real-time (i.e., What You See Is What I See) access to information from a number of different sources, including a university, the Web, and local networks as well as other students and teachers. Students are free to perform activities, find information, conduct experiments, and engage in collaborative activities to obtain information. Since the system supports both synchronous and asynchronous communication, the collaborative activities can occur either at the same or different times.

The current application comes equipped with a number of collaborative capabilities that enable teachers and students located in different geographical locations to "enter" each other's worlds. For example, the system allows groups to share applications and perform a specific task such as completing an experiment, writing a paper, using a software package. Thus, the major software components include (1) a special graphical user interface, (2) support programs that manage the communications and data gathering functions, and (3) administrative programs that support activities such as student/group registration and report generation. The special graphical user interface consists of a shared Browser for the WWW, and a set of collaborative tools that permit groups to chat, use a whiteboard, and share both applications and files. The support programs that manage the communications and data gathering functions include a polling application that maintains the user and group lists, and a suite of programs that create, maintain, and update the database. Finally, the system performs administrative functions such as installation, student and group registration, and report writing.

## Evaluation

As previously mentioned, a major component of this research is the evaluation of the effectiveness of the collaborative interface to determine what is and is not effective. During the past two years, over 400 students have used the collaborative software in seven different courses. Courses using the collaborative courses were compared to control courses using a pre-test post-test, matched controls design. The evaluation was designed to determine the effect of the collaborative technology on student learning outcomes, student attitudes, and attitudes about collaboration. Results from comparisons of just the performance variables (i.e., that course grades and scores on the questions concerning analysis and synthesis of information) indicate no significant difference between the control and experimental groups.

We also collected information from the computer sessions through our data collection programs. The system logs information such as source, time, and type of interaction. Thus, we were able to capture a detailed record of the types of activities that students (and groups) perform while using the interface. Analysis of this data indicates that group chat was the most frequently

used collaborative tool regardless of course content or activity. The shared web browser was the second most frequently used tool, while usage totals for all other tools corresponded to the type of task that was performed by a particular group. The system log information was also correlated with factors such as age, a student's major, and gender and indicated that these variables often impact a group's productivity (as measured by total time to complete a task and the activities performed during the task). For example, students enrolled in non-technical courses used the chat tool more frequently and longer than students enrolled in science course. Groups who were dissatisfied with the system did not necessarily perform less well than groups who were satisfied. And finally, as network delays increased, remote groups spent more time managing their work or verifying that a message had been either sent or received. Although our observations seem sound, they are based on a limited amount of data. In the next year, we will gather additional information about a group's work, learning, and communication style to determine their effect on distributed problem solving.

From both observation and data gathered during the project, a number of conclusions were made concerning how students used the interface and which parts were successful and unsuccessful. These conclusions are as follows:

1. Students seem unable to manage multi-tasking or multiple windows. As new applications are opened, existing windows or applications are hidden. Once removed, students mistakenly believe that the application has shut down and must be re-opened. This can reek havoc in a synchronous communication environment.

2. Students seem unable to distinguish between the different modes of a computer. For example, they fail to understand that there is a difference between "shared" and "individual" modes of work.

3. Students need to know how to map the computer-collaborative tools onto the specific tasks. (I.e., Which collaborative tool should be used for which task?).

4. Students become frustrated when they do not know what other members of the group are doing. As the students become more proficient with the software, they learn to use awareness tools that provide them with information about the other members of the group.

5. Students lack metaphors for shared software applications. As a result, they have no established protocol for how to interact with team members while using this type of software.

We also examined the various collaborative exercises used in this project to determine which factors contributed to success. Examples of these activities can be found on the project's web page (i.e., www.vcuproject.edu). The types of activities developed by different faculty tend to vary according to the nature of a particular discipline and the faculty member's particular style. However, based on both observation and data, we are able to make a number of conclusions about what types of tasks were most successful. For example, successful collaborative experiences tended to be both extremely focused and small. Initially, faculty members modeled their collaborative exercises after classroom exercises in which both groups and teacher are free to roam around the room. Unlike the classroom, however, a teacher cannot always sense when a group is frustrated or confused and must often wait until it is too late to correct the problem. As a result, many of the computer-supported collaborative activities were scaled down to accommodate the loss of visual cues. At the same time, the set of instructions provided to students were greatly increased and posted on both the faculty and course web pages.

We also found that it was not always possible to adapt a classroom group activity to a computer-supported collaborative environment. Tasks that worked well in the classroom did not always translate into the new environment. One such activity was an environmental science project that asked students to collect data on a number of different events and then share this data with other members of the group. Given the location of the data collection source (e.g., an outdoor pond), it was neither convenient nor possible for students to share their data in a machine-readable format. As a result, the collaborative software became more a hindrance than help in supporting collaboration.

Data on faculty satisfaction also tended to vary. Faculty were surprised that Internet communication was sometimes slow and inconsistent. While some faculty experienced no problems with the hardware or software, others were overwhelmed with the technology. Successful experiences with both software and student collaboration tended to occur when the faculty member was well organized, and the student activities were well structured, small, and self-contained. As the complexity of the educational activity increased, the level of unsatisfaction among both faculty and students also increased. Finally, our interviews with faculty that participated in this project clearly indicate that most do not realize that collaborative skills have not been mastered at an earlier age. However, our data suggests that most students lack both organizational and interaction skills and, as a result, often end up working alone to complete the task. For example, the most frequent statement recorded in or study's database was the question: "Ok, what do we do now?" This is then followed by a series of responses, all echoing the phrase, "I don't know." As a result, the training sessions included information about the use of the system and how to collaborate. For example, students were shown how to use the chat tool to establish their group's procedures and distribute the work. After such training, the collaborative exercises were much more successful.

## Conclusions and Impact of Research

In conclusion, we believe that we have identified a number of factors that contribute to successful computer-supported collaboration. After developing a system that supports real-time collaboration for students in different locations, we examined how students enrolled in a number of different courses at the University of North Texas used the software to complete specific tasks. While our research shows that the collaborative system helps most groups work effectively, it also shows that some groups are less successful, perform at a slower rate than face-to-face groups, or are intimidated by the system even after several hours of training. Success with the system seems to be affected by task, training, and experience. Knowledge of how to perform as a leader also seems to be an important factor.

Furthermore, groups' preferences for and use of certain collaborative tools, as well as their use of features within those tools, greatly varies. However, judged by the total time spent completing the task and by their scores on a series of related questions, performance seems unaffected by whether distributed groups used all or some of the collaborative tools. Our studies also show that the collaborative interface allowed groups to brainstorm and co-author documents and, in doing so, encourages both talking and doing in the same meeting. On the other hand, because of the often-restrictive nature of the interface, groups are forced to talk to each other via their fingers rather than their mouths. As a consequence, team members with inadequate typing skills feel inhibited or restrained. In addition, we noticed that many students learned to adjust their communication style and adapt to the more delayed mode required by the chat tool.

In our research, we have found that while software allows groups to work more effectively, group performance is often impacted by a variety of individual personality, communication, and work style preferences. We have also observed that groups tend to react to individual preferences in a number of different ways. Some groups engage in additional procedural or management activities, while others perform fewer clarification or solution activities. It is our observation that the need for low cost, distributed education occurs frequently in this technological society. Yet rarely do we use network technology to actually meet these educational goals, nor do we provide students and teachers with the tools to communicate in this mode. As such, this research should provide insight and software tools for broad-based interactive learning by electronic means. Moreover, it provides a rich research environment that allows us to investigate various issues related to improving the performance of student and organizational teams that work together across distances.

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